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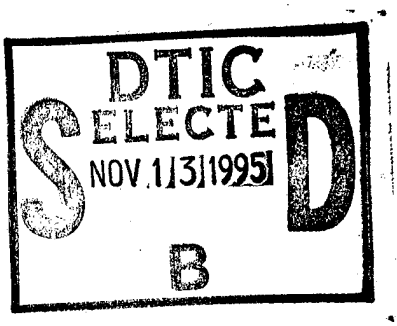

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DEFENSE WOMEN'S HEALTH RESEARCH PROGRAM ANNUAL REPORT:

The Effects of Sustained Operations on Female Soldier Performance

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This annual report for the Defense Women's Health Research Program presents the project status on the sustained operations study comparing female and male soldier performance. An overview of previous sustained operations research and a description of the study's research methodology and measures are given. Soldiers with combat support MOSs will undergo 48 hours of sustained operations in a field environment. During the study period, soldiers will complete cognitive, psychological, and physiological testing along with soldier-relevant performance modules involving record fire, road marches, common task testing, and a computer work environment. Sustained operations research has typically focused on male soldiers with combat arms MOSs. This study augments the present sustained operations database by thoroughly evaluating the performance of female and male combat support soldiers.

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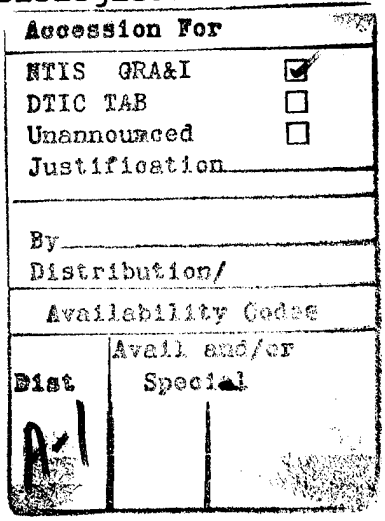

Teresa A. Treadwell 24 Aug 95

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DEFENSE WOMEN'S HEALTH RESEARCH PROGRAM ANNUAL REPORT: THE EFFECTS OF SUSTAINED OPERATIONS ON FEMALE SOLDIER PERFORMANCE

BACKGROUND

Introduction and Relevance

Today's working environment often demands high productivity and performance versatility from its employees. These demands have arisen from business practices such as just-in-time manufacturing, continuous customer servicing, nearly instantaneous communication connectivity, improved transportation, and a streamlined work force. To maintain these productivity and performance characteristics, several occupations or work situations may require prolonged and continuous work periods. Often, employees must sustain effective cognitive and physical performance beyond 8 to 10 hours' duration, unaware of future rest or work termination times (Englund & Krueger, 1985). These work situations include medical services, fire fighting, civil emergency or disaster operations, search and rescue, or change-over periods in manufacturing plants. Although the use of continuous work periods has become important to the functioning of civilian business, it has become more paramount in conducting military operations.

Technological advances in equipment, doctrinal changes, broadened mission requirements, and budgetary constraints have extended soldier performance demands and operational duration. This has been evident during missions in Kuwait, Panama, Haiti, and Somalia. A smaller armed force, deployed according to the force-projection approach to varied humanitarian and war-fighting mission scenarios, may require sustained work periods for pre-deployment, deployment, insertion, mission propagation, and completion phases. The inter-service cooperation and coordination needed to prosecute the "quick decisive" military victory or mission success also uses protracted work periods. As a result, it becomes imperative to examine how soldiers' performance can be maintained and predicted during sustained operations in many different occupational specialties.

In the past, the military has examined sustained work through laboratory, simulation, and field studies of combat arms occupations. However, little field data have been obtained regarding female soldier performance or the combat support or combat service support career fields. This research project, which is funded by the Defense Women's Health Research Program, will examine these issues.

Sustained Operations in the Military

Belenky, Krueger, Balkin, Headley, and Solick (1987) explain that the maintenance of a continuous operations schedule in the military would preclude the usual 6 to 8 hours of sleep per 24 hours of operations. All branches of the armed services have employed continuous operations schedules. With regard to the Army, Field Manual 22-9 (U.S. Army, 1983) explains the use of continuous operations and discusses its implementation. The field manual (U.S. Army, 1983) defines continuous operations (CONOPS) in terms of continuous land combat that affords some opportunity for sleep periods, brief or fragmented in nature.

Two types of continuous operations may be employed: extended operations (work that proceeds continuously with short breaks during a typical shift system, yet is prolonged in length beyond the normal duty day); and sustained operations (SUSOPS) (planned or unplanned continuous work performance without rest or sleep, during which the worker is expected to function as long as possible) (Englund & Krueger, 1985). While extended operations occur more frequently during military operations, sustained work periods are used sparingly. Because resources of U.S. forces are limited, employment of sustained operations would require units to perform with minimal recovery time. Therefore, it is imperative to examine worker effectiveness in sustained operations and recovery requirements.

Methodological Approaches to Sustained Operations Research

The study of worker performance in extended and sustained operations has progressed in two different directions (Belenky et al., 1987). Some experimenters have examined continuous operations with regard to shift work issues (Alluisi & Morgan, 1982; Rentos & Shepard, 1976; Tepas, 1979). Other research has focused on sleep deprivation and work performance (Dinges, Whitehouse, Orne, & Orne, 1988; Kleitman, 1963; Mackie, 1977; Webb, 1982).

Morgan and Pitts (1985) indicate that the military is the most urgent user of research about sustained operations. This research about sleep deprivation and work performance has employed different study methodologies during sleep loss periods. Many researchers have used laboratory evaluations with periodic testing of performance using selected cognitive tasks (Babkoff et al., 1985; Dinges et al., 1988; Froberg, 1977; Webb, 1985). Other studies involved a simulated work environment providing work-related tasks (Angus & Heslegrave, 1985; Banderet, Stokes, Francesconi, Kowal, & Naitoh, 1981; Drucker, Cannon, & Ware, 1969) or a field study

approach using military operations with performance evaluation (Ainsworth & Bishop, 1971; Banks et al., 1970; Bugge, Opstad, & Magnus, 1979; Haslam, 1981, 1984; Kant, Landman-Roberts, Smith, Cardenales-Ortiz, & Mougey, 1985).

These studies have monitored performance tasks such as vigilance, short-term memory, computation, military job skills; collected subjective ratings of mood, alertness, sleepiness, and fatigue; and monitored physiological measures of temperature, heart rate, grip strength, and brain activity. The characterization of performance, psychological state, and physiological functioning during sustained operations affords better understanding of human performance capabilities and opportunities to find predictors of future performance effectiveness.

Sleep Deprivation and Sustained Operations

According to Johnson (1982), work tasks have certain characteristics that determine their sensitivity to sleep deprivation: duration, cognitive work load, operation complexity, amount of previous practice, memory requirements, feedback availability, and task interest. Tasks that are short, well learned, moderate in complexity and mental workload, interesting, and provide feedback appear more resistant to performance decrement when sleep loss occurs. Paralleling these conclusions, Woodward and Nelson (1974) indicate that performance impairment from sleep loss results in slower reaction times, short-term memory decrement, lowered reasoning and decision-making abilities, degraded learning, attention lapses and omissions, and increased feelings of fatigue, irritability, and depression.

Sleep loss causes performance impairment through three mechanisms (Belenky et al., 1987): lapses in wakefulness or micro-sleep periods, reduced arousal producing a lowered capacity for sustained selective attention, and depressed mood and motivation levels, which decrease morale and initiative. Englund, Naitoh, Ryman, and Hodgdon (1983) have indicated that sleep deprivation effects may be tempered by other factors such as physical fitness, prior rest, work and rest cycles, environmental conditions, and motivation.

From these generalizations about sleep deprivation effects, one can conclude that physical work and endurance experience little decrement (Martin, Bender, & Chen, 1986) as do tasks involving well-learned, basic soldier skills during a sustained operations scenario. Generally, the cognitive tasks along with mood, alertness, and motivation suffer when sleep loss occurs.

Circadian Influence on Sustained Operations

During sustained operations, time-of-day or circadian factors may also contribute to differences in performance, psychological state, and physiological functioning (Ryman, Naitoh, & Englund, 1984). According to Naitoh, Englund, and Ryman (1985), these 24-hour rhythmic effects may be controlled endogenously or exogenously. If endogenous, sleep loss will not affect the rhythmic patterns seen over various times of the day. Many studies have observed a circadian component to performance results for tasks involving logical reasoning, encoding, search and identification, vigilance, reaction time, target planning, and surveillance (Babkoff, Caspy, Mikulincer, & Sing, 1991; Bugge et al., 1979; Dinges et al., 1988; Mullaney, Fleck, Okudaira, & Kripke, 1985). Subjective ratings of mood, sleepiness, fatigue, and alertness also have exhibited time-of-day patterns (Babkoff et al., 1991; Bugge et al., 1979; Dinges et al., 1988; Froberg, 1977; Mullaney et al., 1985). Generally, circadian rhythms of performance or subjective measures reveal peaks at late morning or afternoon hours and troughs during late evening or early morning hours (Krueger, 1991). As mentioned earlier, these patterns in subjective ratings can help predict performance rhythmicities.

Physiological measures such as heart rate variability, grip strength, and hormone levels have also exhibited rhythmic patterns during sustained operations (Froberg, 1977; Kant et al., 1985; Opstaad & Aukvang, 1983). In addition, there is a circadian periodicity to both body core temperature (Monk et al., 1985) and human muscle strength (Coldwells, Atkinson, & Reilly, 1994; Hislop, 1963; Wright, 1959). There is some foundation for assuming a causal link between the diurnal variations in strength and core temperature. It has been suggested that these and possibly other body rhythms may be driven by a number of different, as yet undetermined oscillators (Reinberg et al., 1988). In one of the few studies of sustained operations involving women, Froberg (1977) was able to demonstrate that temperature rhythms were maintained during 72 hours of sustained operations during strictly controlled conditions.

Chronic physical activity has been shown to influence some circadian rhythms. Physically active subjects exhibit greater rhythm amplitudes in oral temperature, arousal, alertness, sleepiness, flexibility, muscle strength and self-chosen work rate, alertness and short-term memory (Atkinson, Coldwells, Reilly, & Waterhouse, 1993; Harma, Ilmarinen, Knauth, Rutenfranz, & Hanninen, 1988).

Female Performance During Sustained Operations

Most information concerning sleep loss and circadian effects from sustained operations have been made through the use of male subjects. The few studies that have been performed on females have been conducted in laboratory settings and produced findings similar to male subjects' results. No research involving a direct comparison of female and male performance during sustained operations has been done.

A study by Angus and Heslegrave (1985) required females to maintain continuous task performance in a communications' center simulation and periodically complete cognitive tasks. Results indicated cognitive performance and communications' center processing time declined with sleep deprivation . Research by Froberg (1977) and Dinges et al. (1988) only used intermittent task performance. Both studies indicated circadian patterns of cognitive performance and alertness ratings with significant decrement occurring due to sleep loss. In addition, the Froberg (1977) study found significant circadian affects on oral temperature and adrenaline measurements. All three studies, averaging 52 to 72 hours of sleep deprivation, collected subjective ratings.

Research by Goodman, Radomski, Hart, Plyley, and Shepard (1989) examined endurance maintenance and physiological measures (oxygen intake, blood pressure, gas exchange, lactose levels, heart rate, and hematocrit) during 60 hours of sustained operations. Goodman et al. (1989) found a significant decrease in hemoglobin measurements and heart rate variability during the sustained operations period.

Proposed Research

The U.S. Army Medical Research and Materiel Command has sponsored this research project to examine female soldier performance during sustained operations in a field exercise environment. The experimenter-controlled field exercise rigorously examines soldier skills and capabilities: basic soldier tasks from areas of NBC, first aid, weapons' maintenance and usage, and map reading; physical performance tasks to include road marches, grenade throwing, and a physical performance battery; record fire; and multi-task work environment performance using the SYNWORK program. In addition, a standardized psychological, cognitive, and physiological testing session will be conducted regularly during the exercise to carefully monitor soldier functioning.

To determine whether Army training and doctrine ensure military effectiveness during sustained work by female soldiers, it is imperative to directly compare their performance with that of their male counterparts. Conducting this study in a field environment using performance, subjective, and physiological measures will provide the data necessary to evaluate the generality of previous male soldier data from combat arms occupations.

Experiment Hypotheses

The main objective of this experiment is to compare the effects of sustained operations between male and female soldiers in a field environment. This field study will include examination of cognitive performance; subjective mood, fatigue, and environmental ratings; physiological measurements; and a detailing of soldier operations' schedule. We will determine how sleep deprivation and time of testing factors during sustained operations affect these performance, subjective, physiological measures. Previous sustained operations research has evaluated these factors, yet did not directly examine gender effects. The study's secondary objective is the assessment of decrement in performance efficacy for common soldier tasks along with skills necessary to operate and train in the modern battlefield.

The results of this evaluation will be used to provide information to the Department of Defense about the ability of female soldiers to participate in sustained operations. The evaluation may also identify conditions that may require further research, training, or doctrinal changes to extend the success of the soldier performance during periods of sleep deprivation.

The hypotheses of this experiment are

1. Differences in cognitive performance, subjective ratings, and physiological measures will occur as a function of sleep loss day.

2. Differences in cognitive performance, subjective ratings, and physiological measures will occur as a function of time of testing.

3. Gender differences in cognitive performance, subjective ratings, and physiological measures will occur.

METHODS

Subjects

A total of 24 soldiers (12 females and 12 males) will participate in this experiment. All soldiers will be chosen from one combat support or combat service support military career field: medical, military police, chemical, transportation, petroleum and water supply, maintenance, or signal occupational specialty.

Before the experiment, each soldier will be briefed about the purposes and risks of the study. Volunteers will provide written informed consent in accordance with AR 70-25 and complete a stress level questionnaire, the Life Events Form (see Appendix A). A doctor will review the medical records of each potential test volunteer. Soldiers will be precluded from participation for health conditions or history that prevent them from engaging in field exercise activities or sustained operations during 50 hours of sleep deprivation.

Study Design

As seen in Table 1, the study will cover 6 days. These days are delineated into two types of sessions: control and experimental. Soldiers will be kept in a field environment at Aberdeen Proving Ground where they will complete periodic standardized testing and soldier performance modules involving rifle record fire, soldier common tasks (CTT), road marches, physical performance, computerized multi-task operations, and new technology demonstrations. All test participants will proceed through these sessions to complete the experiment.

During the C0, C1, and C2 control sessions, administrative and regulatory tasks will be conducted, along with baseline data collection about the psychological, cognitive, and physiological measures. The experimental sessions, S1, S2, and S3, comprise the 48 hours of sustained operations during which most of the study's data collection will take place. Other experimenters have used these types of sessions when performing continuous or sustained operations studies (Babkoff et al., 1991; Webb, 1985). Investigators will use a separate experimental area to administer the in-processing, performance testing, subjective measures, physiological monitoring, and out-processing events during the study.

When soldiers are not participating in the periodic practice or record performance of the standardized test sessions, they will be completing other soldier skill-relevant tasks. During the

Table 1

Study Schedule

Control Day 0	Control Day 1	Control Day 2	Experiment Day 1	Experiment Day 2	Experiment Day 3
Session C0. Inprocessing and Briefing. Screening and Trait Measures. Practice on Cognitive and Psychological State Evaluations. Physiological Tests. Introduction to Performance Tasks. Sleep Period. 2300-0645	Session C1. Practice-testing on Cognitive and Psychological Evaluations. Physiological Tests. 2300 Test. Sleep period. 2345-0645	Session C2. 0200 Test. 0500 Test. Breakfast. 0800 Test.* 1100 Test. Lunch 1400 Test. 1700 Test. Dinner. 2000 Test.* 2300 Test. Sleep Period. 2345-0645	Breakfast. Start Session S1. 0800 Test.* 1100 Test. Lunch. 1400 Test. 1700 Test. Dinner. 2000 Test*. 2300 Test. Snack.	0200 Test. 0500 Test. Breakfast. Start Session S2. 0800 Test*. 1100 Test. Lunch. 1400 Test. 1700 Test. Dinner. 2000 Test*. 2300 Test. Snack.	0200 Test. 0500 Test. Breakfast. End Session S2. Start Session S3. 0800 Test*. Debrief. Sleep period.

*Environmental Symptoms Questionnaire (ESQ) only administered at these selected times.

Screening period measures:

General Information Questionnaire

Life Events Form

Psychological Trait Measures

- GEM
- MAACL-R
- EPQ

Testing period measures:

Physiological

- Temperature
- Heart Rate
- Grip Strength

Psychological State Measures

- MAACL-R
- SUBJ
- SRE
- SSS
- ESQ

Cognitive

- Short-Term Memory Recall
- Logical Reasoning
- Spatial Decoding
- Mathematical Calculation

Motor Fine Motor Control

three control sessions and three experimental sessions, these tasks will be administered as performance modules.

Soldiers will wear the battledress uniform (BDU), boots, load-carrying equipment belt, and canteen. During record firing, each soldier will also wear a Kevlar helmet. Each soldier will keep a daily activity log detailing food and drink intake, sleep, and personal activity. Environmental conditions will also be recorded by the experimenters.

Procedure

Study Sessions

Control Session CO

The first day of the experiment will involve administrative processing and sleep regulation of the test participants. The experimental procedure along with certain behavioral restrictions (minimal caffeine and snack food intake along with regulated sleep periods) will be fully explained to the participants. Soldiers will complete the General Information Questionnaire (see Appendix B), providing the participant's medical history, self-rating of physical fitness and activity, and demographic information. In addition, soldiers will answer the Life Events Form to assess the amount and type of naturally occurring stressors experienced at the study's onset, along with the soldier's available resources. This in-processing period will include anthropometric measurements of stature and weight using techniques in the 1988 Anthropometric Survey of U.S. Army Personnel (Gordon et al., 1989).

Psychological trait questionnaires including the General Efficacy Measure (GEM; Sherer et al., 1982), the Multiple Affect Adjective Check List - Revised (MAACL-R; Zuckerman & Lubin, 1985), and Eysenck Personality Questionnaire (EPQ; Eysenck & Eysenck, 1975) will then be administered to test participants. The psychological trait measures administered during C0, along with the state measures used in the following sessions, have been used in previous U.S. Army Research Laboratory (ARL) investigations. The psychological trait measures are designed to periodically assess personality traits, coping resources, and perceptions of stress that may relate to performance of cognitive and other soldier tasks (Blewett, Ramos, Redmond, & Fatkin, 1993; Blewett, Redmond, Modrow, Fatkin, & Hudgens, 1994; Fatkin & Hudgens, 1994; Fatkin, King, & Hudgens, 1990).

During control session C0, test participants will be given detailed performance instructions for the standardized test battery, which includes psychological questionnaires, a

cognitive test battery, and physiological measures. The two practice periods with the cognitive test battery and physiological measures will be coupled with the administration of the psychological trait measures and state measures. The CO session will also have practice periods on the SYNWORK and physical performance test battery modules. At the conclusion of the CO session, soldiers will have a designated sleep period from 2300 hours to 0645 hours.

Session C1

Test participants will have two more practice sessions involving the psychological state measures, cognitive test battery, fine motor control task, and physiological measures (see Table 1) during Control Session C1. These 1-hour practice periods will be held at 0800 and 1400 hours. The period at 1400 hours will establish a practice baseline for the standardized testing periods. When soldiers are not involved in these sessions, they will participate in the physical performance test battery, road march, record fire, CTT, and SYNWORK modules mentioned earlier.

At 2300 hours in Session C1, soldiers will begin record performance of the standardized psychological, cognitive, and physiological measures. This session, along with the eight remaining C2 testing periods, will establish 24 hours of baseline data for comparison with the sustained operations sessions. To complete the 0200 and 0500 hours' testing periods, soldiers' sleep will be interrupted. The testing periods are necessary to capture circadian trends.

Session C2

On the experiment's third day, Control Session C2, the soldiers will undergo standardized testing periods every 3 hours (see Table 1). The Environmental Symptoms Questionnaire (Sampson & Kobrick, 1980), an assessment of the soldier's physical symptom states, will only be administered at 0800 and 2000 hours. Whenever the soldiers are not being tested, they will be completing tasks in the physical performance test battery, road march, CTT, and SYNWORK modules. Investigators will record environmental conditions while soldiers complete their daily activity logs.

As in Session C1, test participants will be instructed to sleep from 2345 hours to 0645 hours. Thus, when the sustained operations session begins, the soldiers should not be experiencing sleep deprivation.

Sessions S1, S2, and S3

Test participants will then perform 48 hours of sustained field operations from 0800 hours on Experiment Day 1 to 0800 hours on Experiment Day 3. Monitoring by investigators will ensure that soldiers do not sleep during this period. At 0800 hours, test participants will receive the standardized psychological, cognitive, and physiological tests given in session C2. As seen in Table 1, these tests will be repeated every 3 hours, except for the Environmental Symptom Questionnaire (ESQ) given at 0800 and 2000 hours only. This inter-test period affords an integral number of tests necessary to follow a 24-hour circadian cycle across the 2 days of sleep loss (Babkoff et al., 1991).

When not participating in the testing sessions, soldiers will complete field duties and tasks of the soldier performance modules. Daily activity logs will be kept during the 48 hours of sustained operations. Once soldiers begin the sustained operations' sessions of the experiment, S1 and S2, investigators will attempt to minimize time clues and not divulge the length of the sleep deprivation period. This is necessary to lessen motivation and temporary activity level increases attributable to awareness of data collection periods.

After 48 hours of sustained operations, soldiers will undergo a final testing session, S3, at 0800 hours. This session will include all the physiological, cognitive performance, and psychological measurements. At this time, the daily activity logging and field performance duties will also cease. The soldiers will then be debriefed about the study and will complete a regulated rest period for sleep recovery (Woodward & Nelson, 1974).

Standardized Testing Periods

Standardized testing periods will be used to regularly examine the effects sustained operations on soldier performance, psychological perceptions, and physiological functioning. These periods will allow delineation of circadian rhythm and sleep loss contributions to the soldiers' effectiveness. Each testing period lasts approximately 60 minutes and has four components: psychological questionnaires, a cognitive test battery, a manual dexterity task, and physiological measures.

Psychological Questionnaires

The psychological questionnaires will be used to assess the soldier's perceptions of stress, mood, alertness, and physical well-being throughout the study. The Multiple Affect Adjective Check List - Revised (MAACL-R; Zuckerman & Lubin, 1985), Subjective Stress Scale (SUBJ; Kerle & Bialek, 1958), and the Specific Rating of Events scale (SRE: Fatkin, King, & Hudgens, 1990) will provide period-specific stress ratings. The Stanford Sleepiness Scale (SSS; Hoddes, Zarcone, Smythe, Phillips, & Dement, 1973) and the Environmental Symptoms Questionnaire (ESQ; Sampson & Kobrick, 1980) will be used to assess soldier alertness and physical well-being. Completion of these questionnaires will take 15 minutes.

Cognitive Test Battery (CTB)

The Cognitive Test Battery will be administered after the psychological questionnaires. The 15-minute battery consists of a series of timed pencil and paper tests measuring verbal memory (Thorndike & Lorge, 1944; Williams, Gieseking, & Lubin, 1966), logical reasoning (Baddeley, 1968), addition computations (Williams & Lubin, 1967), and spatial rotation abilities (Shepard, 1978). Each test set contains different versions of the battery for repeated administrations to minimize learning effects. This battery was originally developed by the U.S. Army Research Institute of Environmental Medicine (Blewett et al., 1994). It has been revised by ARL's Human Research and Engineering Directorate (HRED) to balance cognitive difficulty and include mathematical calculation, spatial rotation, and word recall tests. Soldiers will have three practice sessions with the battery.

Manual Dexterity Task

Following the CTB, the soldiers will attempt the fine motor control task involving placement of hex nuts on the screws of the manual dexterity board (see Figure 1). Task completion time will be limited to 60 seconds.

Physiological Measures

Test participants' oral temperature, grip strength, and heart rate will be obtained. The physiological data collection should last approximately 10 minutes.

Oral temperatures will be measured using a digital thermometer (Yellow Springs model 4000) and a general purpose probe covered by a disposable, sterile plastic sheath

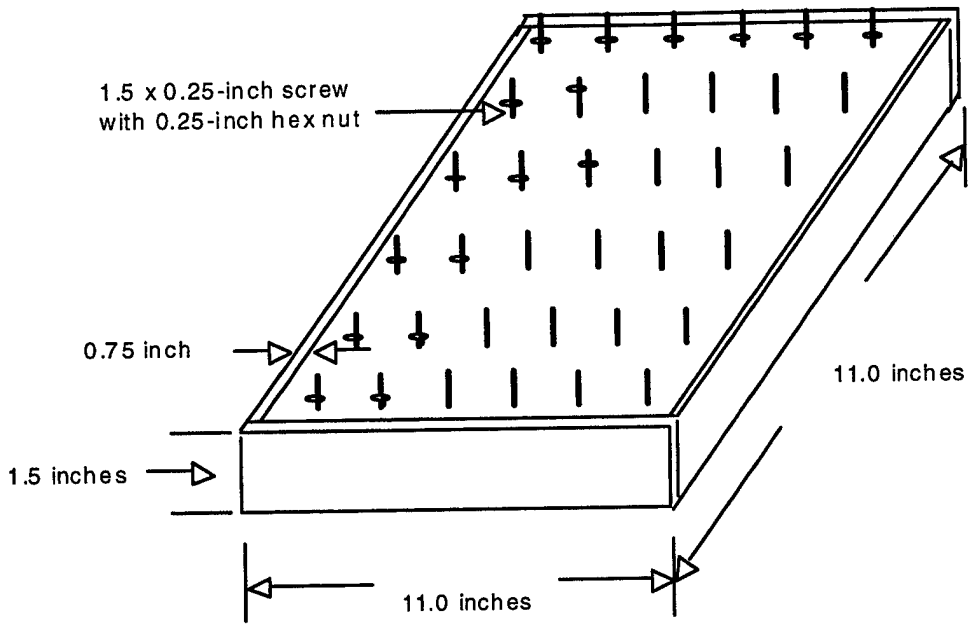

Figure 1. Manual dexterity board.

(Steritemp). Before the measurement, the test participants will refrain from consuming fluids and will be seated and still. The temperature probe will be placed in the subject's mouth under the tongue for approximately 3 minutes to allow a stabilized temperature recording.

During temperature measurement, resting heart rate will be obtained by palpation at the radial artery. A single 10-second count will be multiplied by six to serve as the criterion measure.

Each soldier's hand grip strength will be determined on the dominant hand. The test participant will grasp a strain gauge hand grip dynamometer and will exert a maximum voluntary isometric contraction. The soldier will hold the contraction for 3 to 5 seconds and then relax. Initially, five contractions will be elicited, and the mean of the last two will serve as the baseline measure. During later testing periods, only two contractions will be elicited, and the mean of these will serve as the performance measure (Ramos & Knapik, 1979). Grip strength, oral temperature, and heart rate will be noted on a data sheet, along with the subject's fine motor performance.

Performance Modules

Throughout the experiment, soldiers will complete the modules that involve soldier skills important to successful battlefield performance.

Physical Performance Test Battery

The Physical Performance Test Battery is designed to test various physical capabilities of the soldier. This 1-hour battery consists of five tasks: the Grenade Throw for Accuracy; the Grenade Throw for Distance; the Medicine Ball Put; the Vertical Jump; and the 50-Meter Sprint. The battery will be administered each study day for examination of soldier fitness, power, anaerobic capacity, and coordination (Knapik et al., 1993). Soldiers will receive task training on the first study day. Before task performance is recorded, soldiers will be afforded practice trials.

Road March

Soldiers will perform standard military road marches on a mixture of paved and dirt roads (U.S Army, 1990). The test participants will wear a load-carrying equipment (LCE) belt and canteens. The total load on these marches, including uniform and boots, will not exceed 40 pounds. The soldiers will march together at route step, maintaining a pace of 3 miles per hour over a 5-kilometer route.

Record Fire

Soldiers will shoot the M16A2 rifle for two trials of record fire. The Standard Operation Procedures for the Use of M-Range, dated 14 June 1991 (HEL SOP No. 385-7) will be followed during the record fire module. The soldier's M16A2 weapon with iron sights will be zeroed according to established zeroing procedures before each day's firing trials.

Soldiers will undergo a practice and record fire session. A 5-minute rest period will occur between sessions. During each session, the soldier will be given a 30-round magazine and will assume a foxhole-supported firing position. When the soldier has announced preparedness to fire, an 18-target scenario will be presented with instructions to hit as many of the targets as possible with the weapon in the semi-automatic mode. Again, the targets will appear randomly for 2, 3, and 5 seconds at ranges of 75, 100, 150, 200, 250, and 300 meters. The soldier will be told to keep shooting at a target until it is hit and goes down or until the target

lowers as a result of target exposure expiring. There will be a 2-second delay between targets. Three targets will be presented at each range for three different target exposure times. When all targets have been presented, the subject will be told to cease firing and exit the foxhole.

SYNWORK Task

The Synthetic Work (SYNWORK) Environment, developed by the Walter Reed Army Institutes of Research (Knapik et al., 1993), consists of four separate tasks presented simultaneously on a computer screen. The test participant interacts with the computer through the use of a standard mouse. The SYNWORK tasks include the Sternberg memory task (upper left quadrant), the addition task (upper right quadrant), visual monitoring task (lower left quadrant) and the auditory monitoring task (lower right quadrant). Figure 2 includes a picture of the SYNWORK screen. Cumulative scoring is displayed on the computer screen. When the score is updated, additional performance feedback is given by a low (error response) or high (correct response) frequency tone (Knapik et al., 1993).

The soldiers will receive six training sessions to stabilize the performance level. In the first training session, each task will be presented individually for a 2-minute performance period, followed by 5 minutes of performance of all four tasks simultaneously. The other training sessions only have the 5-minute simultaneous task performance. The record SYNWORK sessions will last 20 minutes. Soldiers will complete a questionnaire about the SYNWORK task during the last record session. Appendix C includes the written instructions and questionnaire for SYNWORK.

Common Soldier Tasks (CTT)

The soldiers will be tested in selected basic soldier tasks in modules according to subject area: map reading; first aid; nuclear, biological, and chemical (NBC); weapons usage and maintenance. Administration of the testing modules will follow guidelines in the Soldier's Manual of Common Tasks (U.S. Army, 1994) and will include a brief overview of task standards, followed by performance testing resulting in a "pass" or "fail" score. Each testing module will last approximately 1 hour as soldiers proceed through different task testing stations.

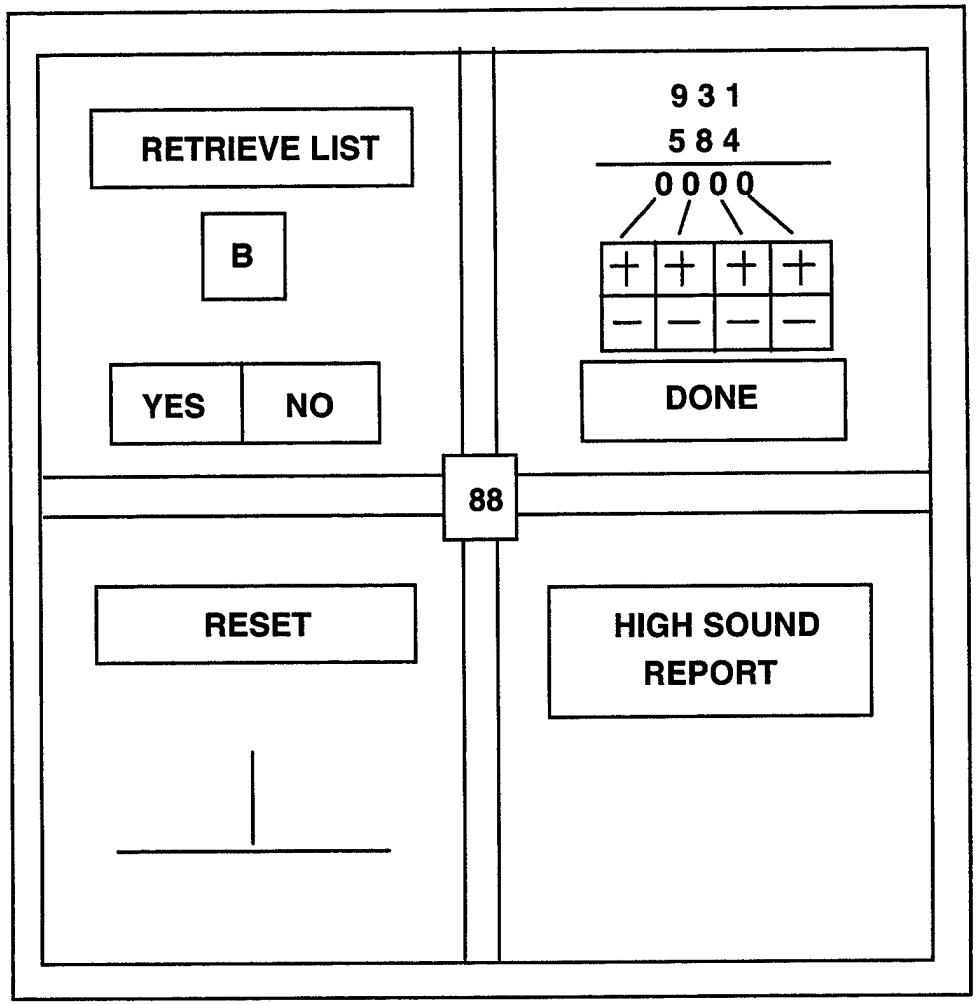

Figure 2. The synthetic work environment (SYNWORK) screen.

Common Soldier Tasks (CTT)

The soldiers will be tested in selected basic soldier tasks in modules according to subject area: map reading; first aid; nuclear, biological, and chemical (NBC); weapons usage and maintenance. Administration of the testing modules will follow guidelines in the Soldier's Manual of Common Tasks (U.S. Army, 1994) and will include a brief overview of task standards, followed by performance testing resulting in a "pass" or "fail" score. Each testing module will last approximately 1 hour as soldiers proceed through different task testing stations.

Data Analysis

The baseline and record testing sessions afford a repeated measures study design with one between-subjects factor (gender) and two within-subjects factors (performance day and testing time). The within-subjects factor performance day has three levels: control, and experiments 1 and 2. There are eight levels of testing time ranging from 0200 through 2300. These factor levels afford examination of the sleep deprivation and circadian effects of sustained operations. The between-subjects factor, gender, has two groups: male and female. All these soldiers will possess military occupational specialties (MOSs) in the same combat support or combat service support career field. It is important to determine if sustained operations have similar effects on performance efficacy of male and female soldiers.

Three-way analyses of variance (ANOVAs) (gender x performance day x time of test) will be performed on the dependent variables involving cognitive performance, physiological measurement, and sleepiness rating. The cognitive performance variables taken from the memory recall, logical reasoning, spatial rotation, and arithmetic calculation tasks include accuracy, solutions attempted, and omission measures. The physiological variables are oral temperature, heart rate, and dominant hand grip strength. Sleepiness rating will be obtained from the Stanford Sleepiness Scale. If significant results are found, post hoc comparisons will be made using Scheffé's Test or Tukey's Honestly Significant Differences (HSD) Test.

Because of the interdependence of the psychological measures, multivariate analyses of variance (MANOVA) will be used on the dependent variables obtained from the subjective questionnaires. These MANOVAs will determine gender, performance day, and testing time effects. Examination of psychological trait measures from the Multiple Affect Adjective Check List - Revised, the General Efficacy Measures (self-efficacy ratings), and the Esyenck Personality Questionnaire (personality dimensions) will be done concurrently in one MANOVA. State measures from the Multiple Affect Adjective Checklist-Revised subscales (anxiety, depression, hostility, positive affect, and sensation seeking), the Specific Rating of Events Questionnaire (overall stress), and the Subjective Stress Scale will be analyzed together. Another MANOVA will be performed on the psychological measures of physical distress, fatigue, heat stress, and wellness ratings from the Environmental Symptoms Questionnaire. Post hoc tests will include Scheffé's or Tukey's HSD comparisons.

Correlation analyses will also be employed to examine possible relationships between personal characteristics, food intake, field performance, and the results of the cognitive battery, subjective ratings, manual dexterity task, and physiological measurements.

Based on ANOVA and MANOVA results, frequency analysis may be employed to delineate the circadian and sleep loss effects of sustained operations on performance, psychological, and physiological measures. Typically, circadian effects induce a rhythmic influence while sleep loss produces a monotonic (decreasing) dimension to these measures. If day and testing time interaction effects are revealed by analysis of variance, the data pattern is more likely to follow a stochastic time series in which period, amplitude, or phase changes may occur over time. In this instance, complex demodulation is needed to determine the monotonic and rhythmic components (Babkoff et al., 1991; Sing, Thorne, Hegge, & Babkoff, 1985).

PROJECT STATUS

Progress

As shown in Table 2, the project has been completed through Milestone 7, with respect to this interim report date of 1 September 1995. The project's original experiment date in July was postponed because of soldier unavailability from the Ordnance Center and School at Aberdeen Proving Ground, Maryland. During the past months, the majority of the female trainees at the Ordnance Center have been National Guard and Reserve soldiers who were ineligible to participate in the experiment. Presently, we are working with the Ordnance Center on a new experiment week amenable to the soldiers' training and assignment schedules. All the experiment's test equipment and supplies have been procured and readied. Purchases include physiological measurement devices, computer equipment, physical fitness testing tools, and troop field supplies.

Following completion of the experiment week, data analysis and final report preparation will proceed as indicated. The final project report and presentation will be completed by April 1996.

Project Benefits

In addition to the breadth of psychological, physiological, and performance information available from this sustained operations' study, other benefits have resulted. Because of the large number of testing periods necessary to examine circadian effects, ARL-HRED scientists augmented the U.S. Army Research Institute of Environmental Medicine cognitive battery to

include arithmetic computation tasks and a spatial rotation task. In addition, the word list task was changed so that subjects would have to write the words from short-term memory, not merely recognize them embedded in sentences. With 30 versions now available for these tests, researchers can more carefully examine soldier's cognitive performance of short-term memory storage and recall, logical reasoning, working memory, and spatial ability. Along with these cognitive tasks, a manual dexterity task has been developed, which can determine fine motor control. Information from these performance tests provides important sleep deprivation data for the Army's HARDMAN analysis tools.

Table 2

Project Milestones

Milestone	Action	Date
1. Research Protocol Approval by Ft. Detrick	Completed	Jan 95
2. Work Unit Summary	Completed	Apr 95
3. Test Equipment Procurement	Completed	Jun 95
4. Coordination with Ordnance Center and School for Subjects	In-Progress	May 95-Present
5. Research Protocol Amendment Approval for APG Test Site	Completed	Jun 95
6. Experiment Data Collected	Postponed	Sep 95
7. Project Interim Report	Completed	Aug 95
8. Project Data Analysis		Sep-Nov 95
9. Project Final Report		Apr 96
10. Project Presentation		Apr 96

The physical performance battery given daily in the study has been especially developed by HRED's physiologist. This battery measures various facets of a soldier's physical fitness, strength, and coordination through jumping, throwing, and running tasks. Collection of these data during sleep deprivation periods provides important information about female soldiers' physical capabilities.

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APPENDIX A

Life Events Form

LIFE EVENTS FORM I

1. Check the appropriate response: "I have recently experienced:"

   Unusually low stress _____
   Mild stress _____
   Moderate stress _____
   High stress _____
   Unusually high stress _____

2. Have you recently experienced any events having an impact on your life? Yes ____ No ____
   Please list them and indicate them as positive or negative by placing them in the corresponding column:

POSITIVE	DATE EVENT OCCURRED

NEGATIVE	DATE EVENT OCCURRED

3. How would you rate the way you handled any events that occurred?

   Very well _____
   Well _____
   Adequate _____
   Poorly _____
   Very Poorly _____

4. "Considering all that has happened recently, my resources for responding to the events were:"

   More than adequate _____
   Adequate _____
   Less than adequate _____

APPENDIX B

General Information Questionnaire

FS,95

ID # _____

GENERAL INFORMATION QUESTIONNAIRE

Please answer all questions by filling in the blanks as completely as possible. All information will be kept strictly confidential. The information is important for test purposes and will not be used for any other purpose.

1. SSN _____

2. Today's Date _____

3. Time _____

4. MOS Primary _____ Time in MOS _____ _____ (years) (months)

Secondary _____ Time in MOS _____ _____ (years) (months)

5. Length of service _____ _____ (years) (months)

6. Date of Birth _____

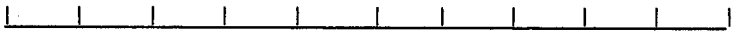
7. Present Pay Grade _____

8. Education completed:
High School _____ (years)
College _____ (years)
Grad School _____ (years)

9. Height _____

Weight _____

10. On the scale below, place a mark on the line to indicate how important the completion of the study requirements are to you.



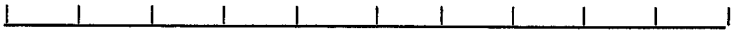
0 10 20 30 40 50 60 70 80 90 100

not important at all — extremely important

Please explain why:_____

_____

11. On the scale below, please rate how willing you are to participate in this study:



0 10 20 30 40 50 60 70 80 90 100

not at all — very willing

12. PHYSICAL ACTIVITY

a. In regard to overall physical activity, how would you describe your life?

Very Inactive	Somewhat Inactive	Average	Active	Very Active
_____	_____	_____	_____	_____

b. How many <u>times per week</u> do you engage in any regular physical activity (like jogging, bicycling, etc.) long enough to work up a sweat?

None	1	2	3	4	5	6	7 or more
___	___	___	___	___	___	___	___

13. PHYSICAL FITNESS: Compared to others of your age and sex, how would you rate your:

	Far Below Average	Below Average	Average	Above Average	Far Above Average
a. Endurance	_____	_____	_____	_____	_____
b. Sprint Speed	_____	_____	_____	_____	_____
c. Strength	_____	_____	_____	_____	_____
d. Flexibility	_____	_____	_____	_____	_____

14. To the best of your recollection, list your most recent Army Physical Fitness Test (APFT) <u>raw scores</u> and APFT <u>total points</u>:

a. Number of Push-ups _____

b. Number of Sit-ups _____

c. Two-mile run time (min : sec) _____:_____

d. Total APFT Points _____

15. Present overall health: (check one)

(1) _____ excellent
(2) _____ good
(3) _____ fair
(4) _____ poor

16. Have you experienced any of the following health symptoms?:

	Yes	(Time Occurred)	No	Don't Know
Frequent or sever headaches	___	_____	___	_____
Dizziness or fainting spells	___	_____	___	_____
Sinusitis (Sinus headache)	___	_____	___	_____
Head injury	___	_____	___	_____
Palpitation or heart pounding	___	_____	___	_____
Heart trouble	___	_____	___	_____
High or low blood pressure	___	_____	___	_____
Loss of memory or amnesia	___	_____	___	_____
Black-outs	___	_____	___	_____
Excessive worrying or anxiety	___	_____	___	_____

17 List any other health problems currently affecting you:

_____

_____

_____

18. Are you **presently** taking any medicines or drugs for medical reasons?

_____ yes _____ no

If yes, what kind(s)? _____

For what condition? _____

Date you began using this medicine or drug _____

19. Other than those listed in question 18, have you taken medicines or drugs for medical reasons at any time during the past 3 months?

_____ yes _____ no

If yes, what kind(s)? _____

For what condition? _____

_____

20. Are you presently receiving any hormone treatments (not including birth control pills)? _____ yes _____ no

If yes, what kind(s)? _____

For what condition? _____

_____

21. Other than those listed in question 21, have you received any hormone treatments at any time during the past 3 months?

_____ yes _____ no

If yes, what kind(s)? _____

For what condition? _____

22. How many hours of sleep do you normally get on week nights? _____ on weekends? _____

23. Are you following any special diet right now? (check one)

_____ yes _____ no

If yes, explain: _____

_____

24. Have you ever had any surgery that affected your reproductive system? (check one)

_____ yes _____ no

If yes, explain:

_____

_____

25. Do you find you are over tired: (check one)

(1) _____ never

(2) _____ occasionally

(3) _____ frequently

26. Do you consider yourself: (check one)

(1) _____ right-handed

(2) _____ left-handed

(3) _____ ambidextrous (right for some tasks, left for others)

27. Which hand do you use to write with: (check one)

_____ right _____ left

28. Do you smoke cigarettes? (check one) _____ yes _____ no

If yes, approximately how many per day? _____

29. Are you pregnant? (check one) _____ yes _____ no

30. At what age did you have your first period? _____

31. Are you taking birth control pills? _____ yes _____ no

32. If you <u>are</u> presently taking birth control pills:

    (1) what brand of pills are you taking: _____

    (2) how long ago did you start taking birth control pills _____

33. If your are not presently taking birth control pills:

    Have you recently stopped taking birth control pills

    (within the last 3 months): _____ yes _____ no

34. Have you ever had a child? _____ yes _____ no

    If yes, how many? _____

35. Are your periods: (check one)

    (1) _____ always regular and predictable

    (2) _____ usually regular and predictable

    (3) _____ irregular and unpredictable

    (4) _____ other. Explain:

    _____

    _____

36. Have you missed a period during the last 3 months?

    _____ yes _____ no

    Do you miss periods: (check one) (1) _____ never

    (2) _____ occasionally

    (3) _____ frequently

37. Do you usually keep track of when your next period will start? (check one)

    _____ yes _____ no

If yes, what method(s)

Do you use?

(1) _____ memory

(2) _____ mark calendar

(3) _____ count birth control pills

(4) _____ other. Explain

_____

_____

38. What was the starting date of your most recent menses (first day of your period)?

_____

39. Do you suffer from menstrual cramps or other menstrual symptoms that are severe enough to keep you from performing your regular duties? (check one)

(1) _____ never

(2) _____ occasionally

(3) _____ frequently

40. Do you use an I.U.D. (intra-uterine device)? _____ yes _____ no

APPENDIX C

Synthetic Work Environment (SYNWORK) Instructions and Questionnaire

WRITTEN INSTRUCTIONS FOR SYNWORK TASK

The goal in this test is to score as many points as you can in 20 minutes. The computer screen is divided into 4 quarters with a different task in each quarter and total number of points earned shown in the center. The frequency of each task, except addition, will be controlled by the computer. To maximize your points try to do as may addition problems as you can. You decide how to divide your time amongst the four tasks.

To learn the SYNWORK task you will have some practice sessions in which each of the 4 tasks is presented one at a time for 2 minutes, and then together for 5 minutes. You will have a total of 6 practice sessions.

Note: **You must sit at the same computer assigned for all SYNWORK sessions.**
You will perform each task by using the mouse to click on appropriate buttons on the computer screen.
You should use your PREFERRED HAND to operate the mouse.
You may press either button on the mouse to perform the test.
All errors on all tasks will be followed by a low sound (like a 'blub' sound) and correct responses will be followed by a high sound (like a 'tink' sound).

PRACTICE Sessions: Before starting each module, you will be asked to enter the 5-character subject identifier. Please enter the numbers 9 5 2 and your subject number (i.e. 02). Your 5-character subject identifier would be 9 5 2 0 2. Hit the ENTER key after you have entered your subject identifier correctly. YOU WILL ENTER THIS SAME 5-CHARACTER IDENTIFIER EACH TIME YOU PERFORM THE SYNWORK TASK. IF YOU HAVE ANY QUESTIONS ABOUT HOW TO DO THIS OR WHAT YOUR IDENTIFIER IS, ASK THE EXPERIMENTERS.

MEMORY TASK (Upper Left) A list of letters will appear briefly for you to memorize. Single letters will be presented and you are to indicate whether the single letter was in the list. Click on YES or NO to answer. If you cannot remember the original list you can retrieve it by clicking on the RETRIEVE LIST box, but this will cost you points.

ADDITION TASK (Upper Right) Click on the + and - boxes to show the sum of each column. When you have solved the problem, click on the DONE box. A new addition problem will appear immediately without any signal.

TRACKING TASK (Lower Left) A cursor will move across the screen towards either end of the straight line. your task is to reset the cursor before it gets to the end of the line. You do this by clicking on the RESET box. You earn more points by allowing the cursor to go further towards the end of the line, but lose points for each second that it stays at the end.

LISTENING TASK (Lower Right) Two tones will be presented periodically. You should click the mouse in the HIGH SOUND REPORT box when you hear the higher tone.

Synthetic Work Environment (SYNWORK) Post Questionnaire

5-CHARACTER SUBJECT ID:_____

Please answer the following questions by circling the number that best answers the question.

1. Indicate how much you either like or dislike the Synthetic Work Environment task.

1	2	3	4	5
Dislike Very Much	Moderately Dislike	Neutral	Moderately Like	Like Very Much

2. How easy or difficult was it to complete the afternoon test sessions?

1	2	3	4	5
Very Difficult	Moderately Difficult	Neutral	Moderately Easy	Very Easy

3. How easy or difficult was it to complete early morning test sessions?

1	2	3	4	5
Very Difficult	Moderately Difficult	Neutral	Moderately Easy	Very Easy

4. How easy or difficult was it to complete ALL of the test sessions during the study?

1	2	3	4	5
Very Difficult	Moderately Difficult	Neutral	Moderately Easy	Very Easy

5. When you were working on the SYNWORK computer task, which task did you find the most difficult to complete correctly? Using the numbers 1 to 4 (1=Hardest task and 4=Easiest), please rank the four tasks according to difficulty. **(Each number should be used only once.)**

____Memory Task

____Addition Task

____Tracking Task

____Listening Task

6. When you were working on the SYNWORK computer task, which task did you find the spend the most time on? Using the numbers 1 to 4 (1=Most time and 4=Least time), please rank the four tasks according to time spent completing. **(Each number should be used only once.)**

____Memory Task

____Addition Task

____Tracking Task

____Listening Task

7. Did the Synthetic Work Environment remind you of any specific work or leisure activities?

_____NO _____YES

If yes, please explain:_____

_____

_____

_____

_____

8. Did you use any particular strategy to score the most points on the Synthetic Work Environment?

_____NO _____YES

If "YES", then PLEASE EXPLAIN this strategy:

_____

_____

_____

_____

_____

_____

9. Do you have any other comments or suggestions about the Synthetic Work Environment?

_____

_____

_____

_____